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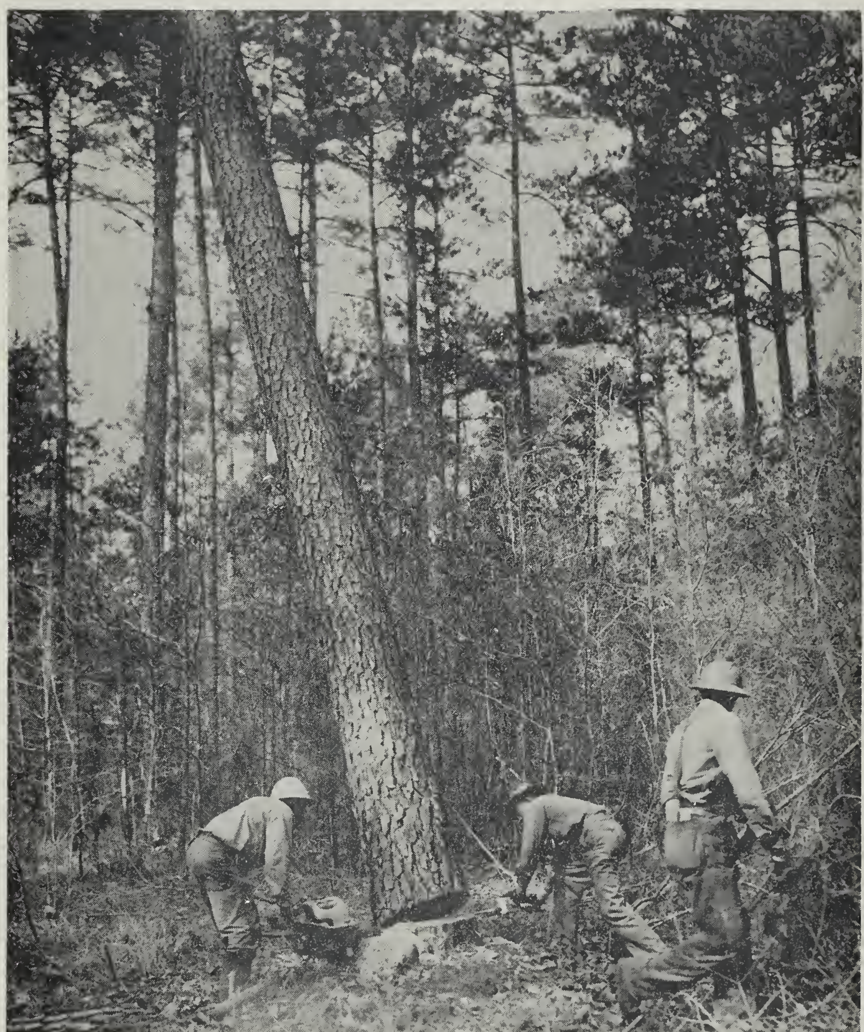

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CUTTING FINANCIALLY MATURE LOBLOLLY AND SHORTLEAF PINE

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This paper offers guides that the forester working with loblolly and shortleaf pine can use to judge when his trees become financially mature. The discussion is restricted to the production of large, high-quality saw timber. Pulpwood, poles, and piling are not considered; forest owners who expect to grow large quantities of these products will need to make special studies following the principles outlined here. The paper deals specifically with the conditions prevailing in the territory around Crossett, Arkansas (fig. 1), but the findings should be applicable on good sites (loblolly site index 80 or better) throughout the range of loblolly pine. (Only shortleaf pines that occur on loblolly sites are considered.)

The guides are not particularly complex in principle, but the alternatives to which they may be applied are numerous. Since their use is enhanced by an understanding of the way in which they were constructed, this paper first describes how the guides were determined and how they apply to the various alternatives encountered in actual management. The last part (pp. 15-16) condenses the guides into a readily usable set of marking rules for use in the woods.

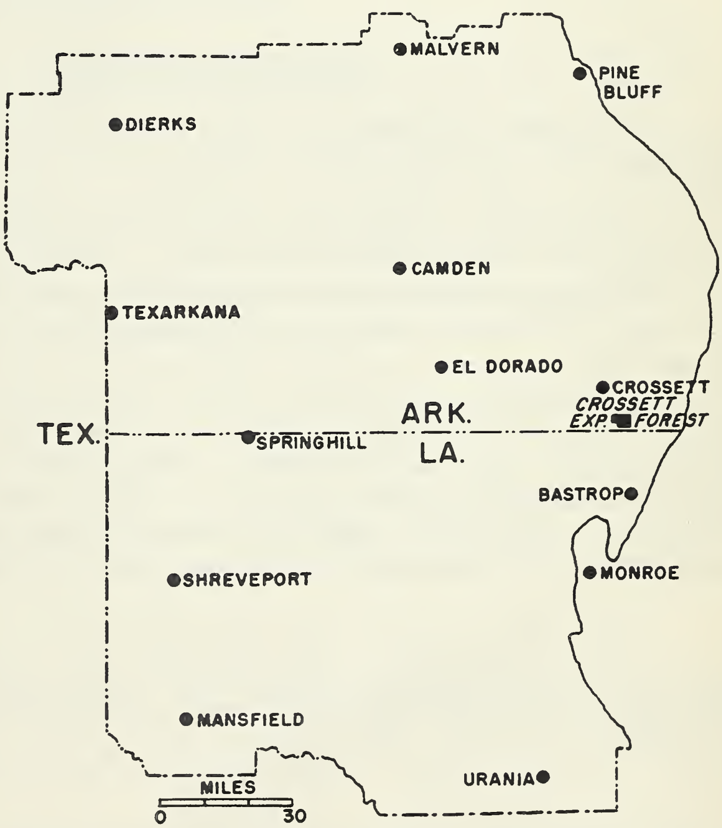

Figure 1.--Crossett territory.

These guides are no universal panacea. They are merely an attempt to attach the dollar sign to the sum of the most important multiple factors that the silviculturist attempts to take into account when he marks a tree for removal. They should, however, help the lumberman to understand tree values. The data on which the guides are based are the best available at present but are lacking in some respects. In the first place, there is not yet any very exact information as to the number and grades of logs that managed trees will contain as they grow from small to large saw-timber diameter classes. Fully objective pine log grades are still in the process of development. In addition, logging costs for trees of various size classes and for varying logging sites and conditions are far from complete. Ideally, each forester would accumulate his own figures and work out his own guides following the principles described in this publication. This would, however, require data not always readily available; an alternative is to adapt the guides offered here, even though they fall short of the ideal, and to use them until more complete data are available.

Estimating Maturity

The guides are based on the cutting of financially mature timber. The idea of financial maturity is this:

The forester visits each acre of his holdings at regular intervals and marks for cutting those trees whose quality or growth rate is below par. Bearing in mind how the typical tree develops--low value at first but rapid increase in value, then a gradual slackening in the rate of increase until the stage is finally reached where the tree ceases to pay its way--the forester appraises his trees with the object of putting the ax to those that are reaching this crucial point. This is the point of financial maturity. Just where it falls is determined by the rate at which the forest owner expects his trees to earn money, the so-called alternative rate of return. 1/ If he expects a return of 4 percent, he will cut any tree that is not producing or will not produce at this rate.

The chief problem with which this paper is concerned, therefore, is to determine the rate of value increase that can be expected from a given pine over a given period of time. This rate will be estimated in two steps:

1/ The choice of an alternative rate is conditioned by risk, taxes, business debts, and the like. See: Duerr, Wm. A., and Bond, W. E. Optimum stocking of a selection forest. Jour. Forestry 50: 12-16. 1952.

1. Calculate the value of trees according to their volume, grade, and diameter.

2. Determine for typical growth rates the prospective rate of increase in tree value.

The proportions of the various sizes and grades of kiln-dried, dressed lumber (dimension and boards) typically produced by the large (Group I) mills of the Southern Pine Association are here used as the basis for appraisal. Many of these mills own and are progressive managers of forest land. Though their chief object is to grow high-grade saw timber, pulpwood and other products will inevitably be harvested from trees or portions of trees that for one reason or another are best not utilized for lumber. Too, appraising trees for lumber does not commit them irrevocably, for at the time of harvest a prudent businessman will put his trees to their most profitable use.

Step one--tree volume, quality, and value

With finished, graded lumber in view, tree volume is here expressed in board feet by the International 1/4-inch kerf rule, using standard volume tables as the guide. [2] Tree quality is developed in terms of the Crossett log grades (pp. 17 to 18). For example, a two-log tree with a grade-1 butt and a grade-3 second log will be classed as grade 1-3. Facility in the use of grades is absolutely essential in making financial maturity decisions. The Crossett log grades are very simple, but in applying them a considerable amount of judgment is required. Such judgment is rapidly acquired with practice.

Tree value will be expressed in terms of conversion surplus. [3] This is the difference between the sales value of the finished lumber and all the direct costs of producing this lumber--mainly labor and materials used in felling the tree and in making, transporting, and sawing the logs. Conversion surplus thus represents that part of a tree's gross product value which can be made available to increase the profit or reduce the loss of the business.

2/ Mesavage, C., and Girard, J. W. Tables for estimating board-foot volume of timber. U. S. Dept. Agr., 94 pp. 1946. (For sale by the Supt. of Documents, U. S. Gov't Printing Office, Wash. 25, D. C., at 25 cents per copy.)

3/ For a full discussion of conversion surplus, see: Guttenberg, Sam, and Duerr, Wm. A. A guide to profitable tree utilization. South. Forest Expt. Sta. Occas. Paper 114, 18 pp. 1949.

Since conversion surplus will here be based upon lumber value, not upon log or stumpage value, the examples to be developed will apply primarily to the timber owner who operates a sawmill and sells his product in the form of finished lumber. However, they will also apply to the log or stumpage seller who can count on receiving for each log or tree a price in line with the value of the lumber it will yield. Indeed, prices would be in line on a freely competitive market if lumber producers and timber growers used such an analysis as a guide.

Lumber sales value. --The first ingredient of conversion surplus, lumber sales value, may be estimated for any tree. Knowing the grade and volume of each log in the tree and the lumber grade yield[4/] of each grade of log, one may determine the amount of lumber, by grades, that the tree will yield. With current sales prices for lumber, he may then calculate the weighted average price per M of lumber represented in the tree, and from this the total lumber value of the tree.

The problem is how to allow for changes in the lumber market. An estimate of financial maturity involves looking ahead at least one cutting cycle--perhaps 5 years or more--and the lumber price level probably will not be the same then as now. To help solve this problem, advantage may be taken of the fact that with all the ups and downs of the lumber market, the price of each grade tends to maintain a fairly stable relationship to that of other grades (see fig. 2). Grade prices may then be expressed as percentages (index numbers) that will have substantial validity over the years, and the value of lumber in a tree may be calculated in index terms instead of dollars, following the same procedure as would be used with dollars.

In figure 2, values in index numbers are plotted for each of the main grades of southern pine lumber. These index numbers were derived from annual average lumber grade prices, expressed as relatives in percent of the price of No. 2 Common. The chart covers the period 1925-51, omitting the abnormal war years 1941 through 1946. The prices used are f. o. b. mill averages received by large producers. Since the annual average price received by these companies for each grade of lumber cannot be far out of line with that obtained by other producers, the prices are assumed to be a close reflection of the entire southern pine market.

4/ As given in Reynolds, R. R., Bond, W. E., and Kirkland, B. P. Financial aspects of selective cutting in the management of second-growth pine-hardwood forests west of the Mississippi River. U. S. Dept. Agr. Tech. Bul. 861, 118 pp. 1944.

From figure 2A it can be seen that though the relative lumber grade prices vary from year to year, they generally fluctuate rather narrowly around constant values. In figure 2B is plotted the total volume of southern pine lumber produced in the United States and in figure 2C the average price received by the companies for their lumber. These three charts show that the relationship among the grade prices is more stable than, and relatively unaffected by, either the volume of production or the price level.

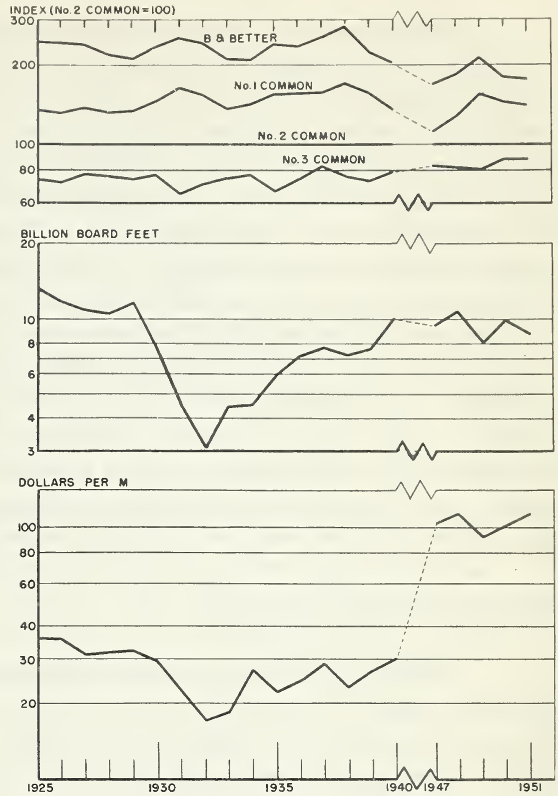

Figure 2.--Top, Relative price of the main grades of southern pine lumber. Middle, Total U. S. production of southern pine lumber. Bottom, Average price of southern pine lumber.

Postwar experience indicates a slight departure from the prewar record. In particular, both B and Better and No. 3 Common lumber grades are now closer in value to No. 2 Common than they were in prewar years. Accordingly, for present purposes, the postwar years are being used as a basis for estimating the price relations likely to prevail into the near future. The estimated index numbers are:

B and Better	185
No. 1 Common (including C finish)	140
No. 2 Common	100
No. 3 Common	85

Direct costs.--The other ingredient of conversion surplus, direct costs of lumber production from stump through mill, is estimated from whatever representative cost records are available. Direct costs include only those additional outlays that arise because the tree in question is being made into lumber. They specifically exclude all fixed or overhead costs--all costs that are unaffected by whether the particular tree is logged and milled.

The cost analyses of the Southern Pine Association indicate that over the years about 60 percent of the total cost of producing southern pine lumber is direct cost. The annual cost summaries[5] for Group I producers were used as a guide to estimate direct costs on a typical operation.[6] Costs were estimated in dollars per M board feet for trees of each diameter class and log height, using available logging and milling study experience.[7] Dollars were then converted to index numbers (percentages of the price of No. 2 Common lumber), just as was done for lumber value. This procedure is defensible on the ground that prices and direct costs (primarily wages) tend to fluctuate together. It permits deriving conversion surplus as an index number, and thus avoiding the problem of fluctuating costs and market prices. The result of these calculations is given in table 1 (pp. 8-10). In the table, columns 2, 3, and 4 list the lumber value, the direct costs, and the difference between these two--the conversion surplus--per M board feet as a weighted average for the tree.

Step two--value increase

Studies on the Crossett Experimental Forest show that desirable growing stock trees will fall into one of the following average growth classes: 1-inch (low vigor), 1.5-inch (medium vigor), or 2-inch (high vigor) average diameter growth per 5 years. Taking these growth classes as given, and with the method described for expressing tree value according to tree size and quality, we are ready for the problem of growth in value. This rate of increase in tree value is the rate that is to be compared with the desired rate of return to determine if a tree is financially mature. The problem will be considered in two stages: first, rate of value increase when a tree changes diameter but not log height or grade; second, rate of increase when height or grade, as well as diameter, changes.

A 5-year cutting cycle will be assumed. That is, it will be supposed that the forester has the choice of cutting a tree now or waiting at least 5 years. Consequently, our interest centers on the rate of tree-value increase in 5 years.

5/ Southern Pine Association. Southern Pine Costs. New Orleans, La. Published annually.

6/ Those interested in allocating total costs will derive final answers not markedly different from the ones given herein.

7/ See publications cited in footnotes 3 and 4.

No change in log height or grade.--Rates of value increase for the given growth classes are worked out in table 1. In the table, columns 2, 3, and 4 show, in terms of index numbers as explained earlier, the lumber value, the direct costs, and the difference between these two--the conversion surplus--per M board feet as a weighted average for the tree. From the number of board feet per tree (column 5), conversion surplus per tree (column 6) was determined. Following this (columns 7, 9, and 11), the prospective conversion surplus per tree after 5 years for each growth class was calculated, assuming no change in log height or grade. The ratio of value after 5 years to value now was then computed, after which compound-interest tables were used to find the annual percentage increase (columns 8, 10, and 12).

As an example of the use of table 1, take the problem of a forester who is deciding whether to cut a 17-inch pine, grade 1-2-3, low vigor. Neither the vigor, merchantable height, nor the grade of the logs is likely to improve soon. The rate of return that the manager follows as his guide is 3 percent. Table 1 indicates that the tree will earn less than this rate--only 2.9 percent--in the coming five years. It is therefore financially mature and should be marked for cutting.

Change in height and grade.--Both log height and grade normally change as a tree grows in diameter. Limbs die and fall off, and clear wood covers the knots. Butt logs of small trees are especially likely to improve radically in grade once the limbs are dropped. Small, short pines of low grade thus are often capable of developing into high-grade trees with 3 or more logs. Imminent and potential changes in log height and grade can be recognized by the experienced forester or woodsman, and to recognize such changes is essential in determining financial maturity. As a general rule, the potential rapid improvement in grade has been realized by the time a pine reaches 22 to 24 inches d.b.h., and the potential merchantable length is usually established by the time the tree is 15 to 17 inches in diameter.

Table 1 may be used for calculating (though not reading directly) the rate of value-increase for trees expected to grow in log height or improve in grade. Suppose that our 17-inch, grade 1-2-3 pine is expected to add a fourth log in the coming 5 years, so as to become an 18-inch, grade 1-2-3-3 tree. Table 1 shows that the value now is index 20.8, and that the value in 5 years (reading in the same column, oposite the expected grade and diameter) will be index 30.1. A calculation of the ratio of these indexes and reference to compound interest tables discloses that the rate of increase is 7.7 percent. If a 3- or 4-percent return is satisfactory, the tree is not yet mature.

Table 1.--Rate of value increase of loblolly or shortleaf pine, by log height, grade, diameter, and vigor class

D. b. h. (inches)	Per M board feet			Lumber per tree	Conversion surplus per tree by vigor class						
						High vigor		Medium vigor		Low vigor	
	Gross lumber value	Direct costs	Conversion surplus		Now	After five years	Annual increase	After five years	Annual increase	After five years	Annual increase
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Index	Index	Index	Bd. ft.	Index	Index	Percent	Index	Percent	Index	Percent
					Tree grade 2-3						
12	129.0	66.5	62.5	92	5.7	8.2	7.5	7.5	5.6	6.9	3.9
13	127.2	65.2	62.0	112	6.9	9.6	6.8	8.9	5.2	8.2	3.5
14	125.9	64.0	61.9	132	8.2	11.1	6.2	10.3	4.7	9.6	3.2
15	124.5	62.7	61.8	156	9.6	12.7	5.8	11.9	4.4	11.1	2.9
16	123.3	61.5	61.8	180	11.1	14.5	5.5	13.6	4.1	12.7	2.8
17	122.1	60.3	61.8	206	12.7	16.4	5.2	15.4	3.9	14.5	2.7
18	121.3	59.2	62.1	233	14.5	18.5	5.0	17.4	3.7	16.4	2.5
19	120.2	58.0	62.2	264	16.4	20.7	4.8	19.6	3.6	18.5	2.4
20	119.3	56.9	62.4	296	18.5	22.9	4.4	21.8	3.3	20.7	2.3
21	118.1	55.8	62.3	332	20.7	25.2	4.0	24.0	3.0	22.9	2.0
22	117.2	54.9	62.3	368	22.9	27.5	3.7	26.3	2.8	25.2	1.9
23	116.4	54.1	62.3	404	25.2	29.9	3.5	28.7	2.7	27.5	1.8
24	115.8	53.5	62.3	441	27.5	32.4	3.3	31.1	2.5	29.9	1.7
25	114.9	53.1	61.8	484	29.9	34.7	3.0	33.5	2.3	32.4	1.6
					Tree grade 1-3						
14	129.4	64.0	65.4	132	8.6	12.2	7.2	11.3	5.6	10.4	3.9
15	129.4	62.7	66.7	156	10.4	14.2	6.4	13.2	4.9	12.2	3.2
16	129.4	61.5	67.9	180	12.2	16.4	6.1	15.3	4.6	14.2	3.1
17	129.4	60.3	69.1	206	14.2	18.8	5.8	17.6	4.4	16.4	2.9
18	129.4	59.2	70.2	233	16.4	21.5	5.6	20.1	4.2	18.8	2.8
19	129.4	58.0	71.4	264	18.8	24.4	5.3	23.0	4.1	21.5	2.7
20	129.4	56.9	72.5	296	21.5	27.6	5.1	26.0	3.9	24.4	2.6
21	129.4	55.8	73.6	332	24.4	30.8	4.7	29.2	3.6	27.6	2.5
22	130.0	54.9	75.1	368	27.6	34.2	4.4	32.5	3.3	30.8	2.2
23	130.4	54.1	76.3	404	30.8	37.8	4.2	36.0	3.2	34.2	2.1
24	131.0	53.5	77.5	441	34.2	41.6	4.0	39.7	3.0	37.8	2.0
25	131.2	53.1	78.1	484	37.8	45.2	3.6	43.4	2.8	41.6	1.9
26	131.6	52.9	78.7	528	41.6	48.8	3.2	47.0	2.5	45.2	1.7
27	132.1	53.0	79.1	572	45.2	52.5	3.0	50.6	2.3	48.8	1.5
					Tree grade 1-3-3						
14	128.5	63.4	65.1	186	12.1	17.0	7.0	15.7	5.3	14.5	3.7
15	127.9	62.2	65.7	221	14.5	19.8	6.4	18.4	4.9	17.0	3.2
16	127.3	61.0	66.3	256	17.0	22.8	6.0	21.3	4.6	19.8	3.1
17	126.8	59.8	67.0	296	19.8	26.1	5.9	24.4	4.3	22.8	2.9
18	126.5	58.7	67.8	336	22.8	29.6	5.4	27.8	4.0	26.1	2.8
19	126.0	57.6	68.4	382	26.1	33.4	5.1	31.5	3.8	29.6	2.6
20	125.8	56.5	69.3	427	29.6	37.5	4.8	35.4	3.6	33.4	2.4
21	125.4	55.5	69.9	478	33.4	41.8	4.6	39.6	3.5	37.5	2.3
22	125.4	54.4	71.0	528	37.5	46.3	4.3	44.0	3.2	41.8	2.2
23	125.0	53.6	71.4	586	41.8	50.9	4.0	48.6	3.1	46.3	2.1
24	124.9	53.0	71.9	644	46.3	55.4	3.7	53.1	2.8	50.9	1.9
25	124.8	52.7	72.1	706	50.9	60.1	3.4	57.7	2.5	55.4	1.7
26	124.7	52.5	72.2	767	55.4	64.2	3.0	62.1	2.3	60.1	1.6
27	124.6	52.7	71.9	836	60.1	69.0	2.8	66.6	2.1	64.2	1.3

Table 1.--(Continued)

D. b. h. (inches)	Per M board feet			Lumber per tree	Conversion surplus per tree by vigor class						
	Gross lumber value	Direct costs	Conversion surplus		Now	High vigor		Medium vigor		Low vigor	
						After five years	Annual increase	After five years	Annual increase	After five years	Annual increase
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Index	Index	Index	Bd. ft.	Index	Index	Percent	Index	Percent	Index	Percent
Tree grade 1-2-3											
14	132.7	63.4	69.3	186	12.9	17.9	6.8	16.6	5.2	15.3	3.5
15	131.6	62.2	69.4	221	15.3	20.8	6.3	19.3	4.8	17.9	3.2
16	130.8	61.0	69.8	256	17.9	24.0	6.0	22.4	4.6	20.8	3.1
17	130.2	59.8	70.4	296	20.8	27.5	5.7	25.7	4.3	24.0	2.9
18	130.0	58.7	71.3	336	24.0	31.2	5.4	29.3	4.1	27.5	2.8
19	129.5	57.6	71.9	382	27.5	35.3	5.1	33.2	3.8	31.2	2.6
20	129.5	56.5	73.0	427	31.2	39.7	4.9	37.5	3.7	35.3	2.5
21	129.4	55.5	73.9	478	35.3	44.5	4.7	42.1	3.6	39.7	2.4
22	129.5	54.4	75.1	528	39.7	49.5	4.5	47.0	3.4	44.5	2.3
23	129.6	53.6	76.0	586	44.5	54.7	4.2	52.1	3.2	49.5	2.1
24	129.9	53.0	76.9	644	49.5	59.9	3.9	57.3	3.0	54.7	2.0
25	130.2	52.7	77.5	706	54.7	65.3	3.6	62.6	2.8	59.9	1.8
26	130.6	52.5	78.1	767	59.9	70.8	3.4	68.0	2.6	65.3	1.7
27	130.8	52.7	78.1	836	65.3	76.4	3.2	73.6	2.4	70.8	1.6
28	131.4	52.9	78.3	904	70.8	82.1	3.0	79.3	2.3	76.4	1.5
Tree grade 1-1-3											
16	132.0	61.0	71.0	256	18.2	25.0	6.6	23.2	5.0	21.5	3.4
17	132.4	59.8	72.6	296	21.5	28.9	6.1	26.9	4.6	25.0	3.1
18	133.0	58.7	74.3	336	25.0	33.1	5.8	31.0	4.4	28.9	2.9
19	133.2	57.6	75.6	382	28.9	37.7	5.5	35.4	4.1	33.1	2.8
20	134.0	56.5	77.5	427	33.1	42.7	5.2	40.2	4.0	37.7	2.7
21	134.3	55.5	78.8	478	37.7	48.1	5.0	45.4	3.8	42.7	2.5
22	135.2	54.4	80.8	528	42.7	53.6	4.7	50.8	3.5	48.1	2.4
23	135.6	53.6	82.0	586	48.1	59.5	4.4	56.5	3.3	53.6	2.2
24	136.3	53.0	83.3	644	53.6	65.4	4.1	62.4	3.1	59.5	2.1
25	137.0	52.7	84.3	706	59.5	71.6	3.8	68.5	2.9	65.4	1.9
26	137.8	52.5	85.3	767	65.4	78.0	3.6	74.8	2.7	71.6	1.8
27	138.4	52.7	85.7	836	71.6	84.5	3.4	81.2	2.6	78.0	1.7
28	139.2	52.9	86.3	904	78.0	91.0	3.1	87.7	2.4	84.5	1.6
29	139.9	53.4	86.5	977	84.5	97.5	2.9	94.2	2.2	91.0	1.5
Tree grade 1-2-3-3											
16	129.2	60.9	68.3	322	22.0	30.1	6.5	28.0	4.9	26.0	3.4
17	128.7	59.5	69.2	376	26.0	34.5	5.8	32.3	4.4	30.1	3.0
18	128.3	58.2	70.1	430	30.1	39.2	5.4	36.8	4.1	34.5	2.8
19	127.9	56.9	71.0	486	34.5	44.3	5.1	41.7	3.9	39.2	2.6
20	127.7	55.6	72.1	543	39.2	49.8	4.9	47.0	3.7	44.3	2.5
21	127.4	54.5	72.9	608	44.3	55.7	4.7	52.7	3.5	49.8	2.4
22	127.3	53.4	73.9	674	49.8	61.7	4.4	58.7	3.3	55.7	2.3
23	127.0	52.6	74.4	748	55.7	68.2	4.1	64.9	3.1	61.7	2.1
24	127.0	51.9	75.1	822	61.7	74.6	3.9	71.4	3.0	68.2	2.0
25	127.0	51.6	75.4	904	68.2	81.3	3.6	77.9	2.7	74.6	1.8
26	127.0	51.4	75.6	987	74.6	87.8	3.3	84.5	2.5	81.3	1.7
27	127.0	51.5	75.5	1077	81.3	94.1	3.0	90.9	2.3	87.8	1.5

Table 1.—(Continued)

D. b. h. (inches)	Per M board feet: Gross lumber value	Per M board feet: Direct costs	Per M board feet: Conversion surplus	Lumber per tree	Conversion surplus per tree by vigor class: Now	High vigor: After five years	High vigor: Annual increase	Medium vigor: After five years	Medium vigor: Annual increase	Low vigor: After five years	Low vigor: Annual increase
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Index	Index	Index	Bd. ft.	Index	Index	Percent	Index	Percent	Index	Percent
					Tree grade 1-1-3-3						
16	131.2	60.9	70.3	322	22.6	31.5	6.8	29.2	5.3	27.0	3.6
17	131.2	59.5	71.7	376	27.0	36.3	6.1	33.9	4.7	31.5	3.1
18	131.4	58.2	73.2	430	31.5	41.4	5.6	38.8	4.3	36.3	2.9
19	131.6	56.9	74.7	486	36.3	47.1	5.3	44.2	4.0	41.4	2.7
20	131.8	55.6	76.2	543	41.4	53.2	5.1	50.1	3.9	47.1	2.6
21	132.0	54.5	77.5	608	47.1	60.0	5.0	56.6	3.7	53.2	2.5
22	132.4	53.4	79.0	674	53.2	66.8	4.7	63.4	3.6	60.0	2.4
23	132.8	52.6	80.2	748	60.0	74.1	4.3	70.4	3.2	66.8	2.2
24	133.2	51.9	81.3	822	66.8	81.6	4.1	77.8	3.1	74.1	2.1
25	133.6	51.6	82.0	904	74.1	89.4	3.8	85.5	2.9	81.6	1.9
26	134.1	51.4	82.7	987	81.6	97.1	3.5	93.2	2.7	89.4	1.8
27	134.5	51.5	83.0	1077	89.4	104.7	3.2	100.9	2.5	97.1	1.7
28	135.0	51.8	83.2	1167	97.1	112.2	2.9	108.4	2.2	104.7	1.5
					Tree grade 1-1-2-3						
16	132.8	60.9	71.9	322	23.2	32.5	7.0	30.1	5.3	27.7	3.6
17	133.2	59.5	73.7	376	27.7	37.6	6.3	35.0	4.8	32.5	3.2
18	133.7	58.2	75.5	430	32.5	43.1	5.8	40.3	4.4	37.6	3.0
19	134.2	56.9	77.3	486	37.6	49.2	5.5	46.1	4.2	43.1	2.8
20	134.9	55.6	79.3	543	43.1	55.8	5.3	52.5	4.0	49.2	2.7
21	135.4	54.5	80.9	608	49.2	63.0	5.1	59.4	3.8	55.8	2.6
22	136.2	53.4	82.8	674	55.8	70.5	4.8	66.7	3.6	63.0	2.5
23	136.8	52.6	84.2	748	63.0	78.5	4.5	74.5	3.4	70.5	2.3
24	137.7	51.9	85.8	822	70.5	86.7	4.2	82.6	3.2	78.5	2.2
25	138.4	51.6	86.8	904	78.5	95.3	4.0	91.0	3.0	86.7	2.0
26	139.2	51.4	87.8	987	86.7	103.9	3.7	99.6	2.8	95.3	1.9
27	140.0	51.5	88.5	1077	95.3	112.5	3.4	108.2	2.6	103.9	1.7
28	140.8	51.8	89.0	1167	103.9	121.1	3.1	116.8	2.4	112.5	1.6
29	141.7	52.3	89.4	1258	112.5	129.7	2.9	125.4	2.2	121.1	1.5
					Tree grade 1-1-1-3						
16	134.1	60.9	73.2	322	23.6	33.2	7.1	30.7	5.4	28.3	3.7
17	134.7	59.5	75.2	376	28.3	38.5	6.3	35.8	4.8	33.2	3.2
18	135.4	58.2	77.2	430	33.2	44.3	5.9	41.4	4.5	38.5	3.0
19	136.2	56.9	79.3	486	38.5	50.6	5.6	47.4	4.3	44.3	2.8
20	137.1	55.6	81.5	543	44.3	57.5	5.3	54.0	4.0	50.6	2.7
21	137.7	54.5	83.2	608	50.6	65.1	5.2	61.3	3.9	57.5	2.6
22	138.7	53.4	85.3	674	57.5	72.8	4.8	68.9	3.7	65.1	2.5
23	139.6	52.6	87.0	748	65.1	81.3	4.5	77.0	3.4	72.8	2.3
24	140.5	51.9	88.6	822	72.8	90.0	4.3	85.6	3.3	81.3	2.2
25	141.5	51.6	89.9	904	81.3	99.2	4.1	94.6	3.1	90.0	2.1
26	142.6	51.4	91.2	987	90.0	108.3	3.8	103.7	2.9	99.2	2.0
27	143.6	51.5	92.1	1077	99.2	117.5	3.4	112.9	2.6	108.3	1.8
28	144.6	51.8	92.8	1167	108.3	126.6	3.2	122.0	2.4	117.5	1.6
29	145.7	52.3	93.4	1258	117.5	136.3	3.0	131.4	2.3	126.6	1.5

Prospective increases in grade and vigor, as well as in height, may be evaluated in the same way. If the grade 1-2-3 low-vigor pine changes to a grade 1-1-3-3 at medium vigor growth in 5 years, the rate of value increase will be even higher, 11 percent.

Maturity Under Woods Conditions

Existing stands generally are comprised of trees of different grades and sizes. The greatest dollar returns will be realized when trees of the highest grade and vigor class are carried to maturity, because for any given desired rate of return, high-grade trees will afford more income than low-grade trees.

Cutting the low-grade or financially mature trees from a given stand does not take the timber manager from low to high grade timber in one jump. In stands composed of low-quality trees, the continuous cutting of financially mature trees may not increase the average grade to any great extent for many years. The use of the financial maturity concept does, however, provide a means by which the low-yielding trees can be recognized and the grade of the remaining trees gradually improved.

Financially mature timber has been harvested from the all-diametered second-growth pine-hardwood stands on the Crossett Experimental Forest for the past 15 years. In 1938, when cutting began, the stands had a volume of 4,800 board feet (Int. 1/4-inch rule) per acre in pines larger than 11.5 inches d. b. h. and a basal area of 48 square feet per acre in pines larger than 3.5 inches d. b. h. Grade of the stands in 1952 is shown in table 2. For stands similar to those on the Crossett Experimental Forest, the proportions in table 2 may approximately forecast the grade improvement to be realized through cutting financially mature timber over a period of 15 or 20 years.

Table 2. --Log grade of managed loblolly and shortleaf pines by tree diameter class, Crossett Experimental Forest, 1952

D. b. h. (inches)	Grade 1 logs	Grade 2 logs	Grade 3 logs
	Percent of cubic volume		
14	19	23	58
16	26	23	51
18	33	23	44
20	41	21	38
22	48	21	31
24	55	20	25
26	63	19	18

Part of the upward trend in log grade make-up of these average trees is due to normal improvement in grade with increase in tree size. Nevertheless, much of it is due to a conscious policy of cutting financially mature timber of all sizes.

Effect of other trees.--In judging financial maturity one cannot, of course, appraise a tree solely on its own merits. Each must be considered as a part of the whole stand, because the removal of one or more trees changes the stand and has its effect on the individual. Every forest tree is in more or less competition with other trees, either present or prospective, and this competition affects the desirability of the tree as an investment. Some trees that seem financially mature when judged by themselves will improve in vigor when one or more neighboring trees are cut. Other trees, despite high earning rates, are financially mature because of their influence on the growth of better quality trees. The principle covering the effect of other trees upon financial maturity is this: The aim of the forester should be to maintain on each acre that volume of timber which, within the requirements of the silvicultural system and the program of regulation, has the greatest possible conversion surplus in trees not yet financially mature. Following this principle will result in securing, from each acre, the highest income that the desired rate of return will afford. (See reference cited in footnote 1 for additional explanation.)

Therefore, where two competing trees both appear to be mature but where removal of one would raise the vigor of the other sufficiently to make it no longer mature, a general rule is to retain that tree for growth which has the higher value now or prospectively--the greater size or higher grade, or the better chance of increasing its size or improving its grade. The other tree should be cut.

As an example, assume that two pines, both of medium vigor, are competing, and that if either is cut the vigor of the other will become high. Following are the pertinent data on these pines, read from table 1:

	Tree A	Tree B
Diameter breast high (inches)	20	19
Grade	1-1-3-3	1-2-3-3
Conversion surplus now	41.4	34.5
Medium vigor:		
Conversion surplus after 5 years	50.1	41.7
Rate of increase (percent)	3.9	3.9
High vigor:		
Conversion surplus after 5 years	53.2	44.3
Rate of increase (percent)	5.1	5.1

If a 4-percent rate of return is desired, one of these trees is mature and should be cut. The other should be left to grow at least one more cutting cycle. Since tree A has the higher value now and prospectively, it should be left to grow.

A comparison of these alternative trees will show the reasoning behind the rule. If the market value of No. 2 Common is $85 per M, tree A is at present worth 41.4 index units; this equals 41.4 percent of $85 or $35.19. Computing the dollar values of these alternative trees shows that the value added to the business over the next 5 years is:

	Cutting Tree A	Cutting Tree B
Value of tree cut, invested at 4 percent compound, earns	$4.28	$3.57
Growth in value of tree left:		
Tree A	...	10.03
Tree B	8.33	...
Total value added to the business	$12.61	$13.60

Since cutting tree B will increase the worth of the business by 99 cents more than the alternative of cutting A, tree A should be left to grow. The rule is designed to cover the majority of the numerous alternatives facing the forester. There will be exceptions, but the virtue of the rule is that it obviates making separate calculations for every alternative that arises.

Two additional points need to be made: The first concerns the conflict between rate of increase in tree value and the ability to increase income. The second is that some decisions require looking ahead two or more cutting cycles.

In the example above, the trees increased in value at equal rates. A somewhat more typical example is that of a low-grade tree of high vigor competing with a high-grade tree of low vigor. The data for two such trees, taken from table 1, follow:

	Tree A (high vigor)	Tree B (low vigor)
Diameter breast high (inches)	18	16
Grade	2-3	1-1-3
Conversion surplus now	14.5	18.2
Conversion surplus after 5 years	18.5	21.5
Rate of increase (percent)	5.0	3.4

If the high-vigor tree (A) is cut, the other can be counted on to improve in growth to that of medium vigor. If 4 percent is the rate of return desired, however, it does not automatically follow that tree B should be cut. By the same calculations as before, and assuming that No. 2 Common is worth $85 per M, the present value of tree A is $12.32 and of tree B $15.47. Cutting either of these trees and computinc the value added to the business over the next 5 years has the following results:

	Cutting Tree A	Cutting Tree B
Value of tree cut, invested at 4 percent compound, earns	$2.67	$3.36
Growth in value of tree left:		
Tree A	...	3.40
Tree B	4.25	...
Total value added to the business	$6.92	$6.76

Since cutting tree A will increase the worth of the business by 16 cents more than the alternative of cutting B, tree B should be left to grow. Now the conflict between the percent of tree-value increase and the ability to increase income can be resolved. The desired rate of return is simply a break-even point below which the forest owner refuses to carry investments. The fact that low-value, fast-growing trees will often increase in value at a faster rate than high-value trees whose growth and rate of increase they inhibit does not always determine the choice of alternatives. Where a choice must be made among 2 or more trees, the one to leave is usually the one that is expected to make the greatest contribution to income between now and the time it becomes financially mature.

While many doubtful cases can be resolved by considering the estimated growth rates over the next 5 years, situations will arise that require looking ahead two or more cutting cycles. This will be particularly true when sawlog-size trees of the lower grades are compared with potentially high-grade trees, including seedlings, that have not yet reached sawlog size. Such problems require looking ahead more than the next 5 years. The calculations of the break-even points follow the same pattern as for those of alternative sawlog-size trees. That is, the potential returns from the smaller trees or seedlings must be balanced against the more immediate returns from the sawlog-size tree.

Other considerations relating to the stand may affect the maturity decision. A tree may be otherwise financially mature and still not ready for harvest if it is needed as a seed source. Again, the need

for holding the cut within a cutting budget, or of building the growing stock towards optimum diameter-class distributions, may well result in leaving for another cutting cycle some financially mature trees. In some areas there may be insufficient timber volume to support a commercial cutting operation despite the presence of financially mature trees; that is, in cutting such trees direct costs would run up far above those in table 1.

On the other hand, the owner may be forced to cut some trees in order to obtain a regular income or a regular supply of logs for a sawmill. In this case the desired rate of return has risen, at least temporarily.

Marking Guides

Those who will apply the foregoing principles in the woods must constantly keep in mind that a large percentage of the trees below 25 to 28 inches in diameter are continuously increasing in log height or in quality as they grow. Table 3 (column 2) shows the probable course of log-length and log-grade development of a typical high-grade loblolly or shortleaf pine, growing 3 inches d. b. h. per 10 years, as it increases from 12 to 24 inches in diameter. As will be noted, a third log usually develops at about 14 inches and a fourth at about 18 inches.

Table 3. --Rate of value increase of typical high-grade, medium-vigor loblolly and shortleaf pines, with and without log height and grade changes

D. b. h. (inches) (1)	Tree grade (2)	Annual conversion surplus increase: With height and grade changes (3)	Annual conversion surplus increase: Without height and grade changes (4)
		- - - - Percent - - -	
12	2-3	11.2	5.6
14	2-2-3	7.8	5.1
16	1-2-3	7.1	4.6
18	1-2-3-3	5.2	4.1
20	1-1-3-3	4.9	3.9
22	1-1-2-3	4.3	3.6
24	1-1-1-3	...	3.3

Column 3 shows the rate of increase in conversion surplus for a tree that develops in height and grade as indicated in column 2. Column 4 shows the rate of value increase if there are no height and grade changes from one diameter class to the next. The comparison between columns 3 and 4 again emphasizes the fact that any tree showing promise of improvement in grade or log length should be permitted to grow at least one more cutting cycle, even though it appears to be at the threshold of financial maturity. Furthermore, the influence of other trees on vigor should be recognized. When trees of low or medium vigor are to be released by cutting, they should be promoted one vigor class before financial maturity is judged.

Among trees that show no promise of development in height and grade, the decision to cut or to leave will depend almost wholly upon the rate of growth and the rate of return desired. For such trees, the data in table 1 can be condensed into a readily usable set of marking guides. Table 4 represents one way of setting up such guides. The diameters refer to the largest size of tree that should be left to grow one more 5-year period; the spread in diameter allows for differences in log height and grade.

Table 4.--Marking guides for trees with no prospective increase in height and grade

Vigor class	Desired rate of return: 3 percent	Desired rate of return: 4 percent
	Tree d.b.h., inches	
High	25-29	21-25
Medium	21-25	16-20
Low	14-18	...

If it is desired to reduce the alternatives facing the timber marker still further, the diameter spreads may be replaced by single diameters for each vigor class. Or, by assuming that better quality and higher vigor trees can be grown from seed, all low-vigor trees above 18 inches, as well as any tree of perhaps 20 inches and over that does not have a grade-1 butt log, might be considered mature.

APPENDIX

Timber Appraisal

In the purchase or sale of timber on the stump, column 2 of table 1 can be used to judge the gross lumber value per M of the different sizes and grades of trees listed. These values can be applied to the estimated tree volumes to appraise the index value of the timber. Multiplying the index value by the prevailing price of No. 2 Common lumber will give the gross lumber value of the standing trees. If volumes per tree and costs as listed are acceptable, column 6 will give conversion index values of trees directly for appraisal purposes. Stumpage growers and producers can both use the values listed in column 6 as a basis for arriving at stumpage prices. It must be remembered, however, that these figures represent conversion surplus and are not direct stumpage values.

Crossett Log Grades For Pine

Pine Log Grade No. 1

Surface-clear logs 10.0 inches or larger in diameter inside bark at the small end, and logs over 16.0 inches in diameter at the small end containing not more than three 2- to 4-inch knots, or the equivalent (usually a maximum of about 6) in small knots. Length 10 feet or longer. Logs of this grade having 15 percent or more of volume lost because of sweep, crook, or other external defects are reduced one grade. A loss of over 40 percent reduces the log to grade 3. A loss of over 50 percent of the volume culls the log. Logs of this grade are expected to produce 25 percent or more of B and B grade lumber or 60 percent or more of B and B and No. 1 C combined.

Pine Log Grade No. 2

Surface-clear logs 8.0 to 9.9 inches d.i.b. at the small end, logs over 8.0 inches containing numerous small knots, or logs over 14.0 inches d.i.b. at the small end containing numerous small knots or up to six 2- to 4-inch knots. Length 10 feet or longer. Logs of this grade having 20 percent or more of the volume lost because of sweep, crook, or other external defects are reduced one grade. A loss of 40 percent or more of the volume culls the log. Logs of this grade are expected to produce 10 percent or more of B and B lumber or 50 percent or more of B and B and No. 1 C grade combined.

Pine Log Grade No. 3

Knotty or crooked merchantable logs 8.0 inches d.i.b. at the small end that do not fall in grade 1 or grade 2 as described above. Length 10 feet or longer. Logs of this grade with 20 percent or more of the volume lost because of sweep, crook, or other external defect are culled. Logs of this grade are not expected to produce over 5 percent of B and B lumber or more than 40 percent B and B and No. 1 combined.

Conditions Applicable to All Grades

Knots.--Small knots are defined as any live or dead branch stubs of any size up to and including 1.9 inches in diameter. Large knots are 2.0 inches or larger in diameter.

Knots that are bunched at one end of a log or one face of a log are not as serious as a number of knots scattered over one or more faces. Logs having such bunched knots are not usually reduced in grade as called for by the above definitions unless crook or rot is also present.

Rot.--Logs showing unmistakable evidence of *Fomes pini* are automatically reduced one grade below that indicated by the knot or surface characteristics. This reduction in grade is in addition to any caused by sweep or other defect.